(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
24 May 2007 (24.05.2007)

PCT

(10) International Publication Number
WO 2007/057063 A1

(51) International Patent Classification:
G06T 5/00 (2006.01) *G06T 7/40* (2006.01)

(21) International Application Number: PCT/EP2006/008342

(22) International Filing Date: 25 August 2006 (25.08.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/282,955 18 November 2005 (18.11.2005) US

(71) Applicant *(for all designated States except US)*: **FOTONATION VISION LIMITED** [IE/IE]; Galway Business Park, Dangan, Galway (IE).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **CAPATA, Adrian** [RO/IE]; 35 Ardilaun Road, Newcastle, Galway (IE). **NANU, Florin** [RO/RO]; Bucuresti, Sect. 4, Str. Izv. Muresului Nr. 13, Bl. D22, Sc. D, et. p,, ap. 32 (RO). **CORCORAN, Peter** [IE/IE]; Cregg, Claregalway, Galway (IE). **CIUC, Mihai** [RO/RO]; Str. Latea Gheorge, nr. 17, Bloc C60, Scara1, Etaj 7, Apt. 45 Sector 6, R-061664 Bucharest (RO). **STEINBERG, Eran** [IL/US]; 137 Granville Way, San Francisco, CA 94127 (US).

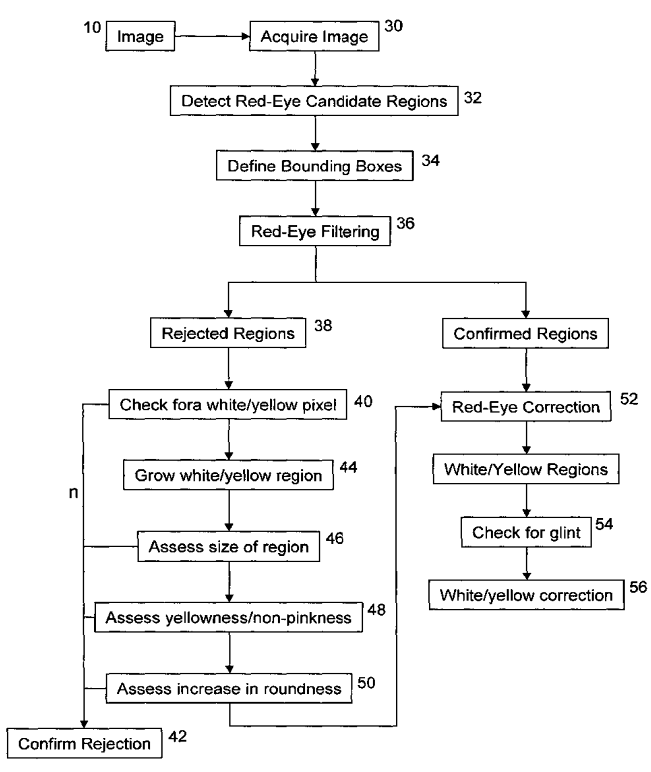
(74) Agents: **BOYCE, Conor** et al.; F.R. Kelly & Co, 27 Clyde Road, Ballsbridge, Dublin 4 (IE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

[Continued on next page]

(54) Title: METHOD AND APPARATUS OF CORRECTING HYBRID FLASH ARTIFACTS IN DIGITAL IMAGES



(57) Abstract: A method for digital image eye artifact detection and correction include identifying one or more candidate red-eye defect regions in an acquired image. For one or more candidate red-eye regions, a seed pixels and/or a region of pixels having a high intensity value in the vicinity of the candidate red-eye region is identified. The shape, roundness or other eye-related characteristic of a combined hybrid region including the candidate red-eye region and the region of high intensity pixels is analyzed. Based on the analysis of the eye- related characteristic of the combined hybrid region, it is determined whether to apply flash artifact correction, including red eye correction of the candidate red-eye region and/or correction of the region of high intensity pixels.

WO 2007/057063 A1

European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

METHOD AND APPARATUS OF CORRECTING HYBRID FLASH ARTIFACTS IN DIGITAL IMAGES

The present invention relates to digital image correction, and particularly to correction of eye artifacts due to flash exposure.

US patent 6,873,743 to Steinberg, discloses an automatic, red-eye detection and correction system for digital images including a red-eye detector module that determines without user intervention if a red-eye defect exists. If a defect is located in an image the portion of the image surrounding the defect is passed to a correction module that de-saturates the red components of the defect while preserving the other color characteristics of the defect region.

WO03/071484, Pixology, discloses a method of detecting red-eye features in a digital image comprising identifying highlight i.e. glint regions of the image having pixels with a substantially red hue and higher saturation and lightness values than pixels in the regions therearound. In addition, pupil regions comprising two saturation peaks either side of a saturation trough may be identified. It is then determined whether each highlight or pupil region corresponds to part of a red-eye feature on the basis of further selection criteria, which may include determining whether there is an isolated, substantially circular area of correctable pixels around a reference pixel. Correction of red-eye features involves reducing the lightness and/or saturation of some or all of the pixels in the red-eye feature.

In many cases, the eye-artifact that is caused by the use of flash is more complex than a mere combination of red color and a highlight glint. Such artifacts can take the form of a complex pattern of hybrid portions that are red and other portions that are yellow, golden, white or a combination thereof. One example includes the case when the subject does not look directly at the camera when a flash photograph is taken. Light from the flash hits the eye-ball at an angle which may provoke reflections different than retro-reflection, that are white or golden color. Other cases include subjects that may be wearing contact lenses or subjects wearing eye glasses that diffract some portions of the light differently than others. In addition, the location of the flash relative to the lens, e.g. under the lens, may exacerbate a split discoloration of the eyes.

A technique is provided for digital image artifact correction as follows. A digital image is acquired. A candidate red-eye defect region is identified in the image. A region of high

intensity pixels is identified which has at least a threshold intensity value in a vicinity of said candidate red-eye region. An eye-related characteristic of a combined hybrid region is analyzed. The combined hybrid region includes the candidate red-eye region and the region of high intensity pixels. The combined hybrid region is identified as a flash artifact region based on the analyzing of the eye-related characteristic. Flash artifact correction is applied to the flash artifact region.

The flash artifact correction may include red-eye correction of the candidate red-eye region. The flash artifact correction may also include correction of the region of high intensity pixels.

A bounding box may be defined around the candidate red-eye defect region. The identifying of the region of high intensity pixels may comprise identifying a seed high intensity pixel by locating said seed high intensity pixel within said bounding box. The seed pixel may have a yellowness above a pre-determined threshold and a redness below a pre-determined threshold. The region of high intensity pixels may be defined around the seed pixel.

The analyzing may include calculating a difference in roundness between the candidate red-eye region and the combined region. The red-eye correction may be applied when the roundness of the combined hybrid region is greater than a threshold value.

The method may include determining to apply red-eye correction when a roundness of the combined hybrid region is greater than a roundness of the candidate red-eye region by a threshold amount.

The method may include determining to not apply correction when the region of high intensity pixels includes greater than a threshold area. The area may be determined as a relative function to the size of said bounding box.

The method may include determining a yellowness and a non-pinkness of the region of high intensity pixels. The acquired image may be in LAB color space, and the method may include measuring an average b value of the region of high intensity pixels and determining a difference between an average a value and the average b value of the region of high intensity pixels.

The analyzing may include analyzing the combined hybrid region for the presence of a glint, and responsive to detecting a glint, determining to not correct the region of high intensity pixels responsive to the presence of glint.

The method may include correcting the region of high intensity pixels by selecting one or more pixel values from a corrected red-eye region and employing the pixel values to correct the region of high intensity pixels. The selected pixel values may be taken from pixels having L and b values falling within a median for the corrected red-eye region.

The method may include determining to not apply correction when an average b value of the region of high intensity pixels exceeds a relatively low threshold or if a difference between average a and b values is lower than a pre-determined threshold.

The method may include converting the acquired image to one of RGB, YCC or Lab color space formats, or combinations thereof.

The analyzing of the acquired image may be performed in Luminance chrominance color space and the region of high intensity pixels may have a luminance value greater than a luminance threshold, and blue-yellow chrominance values greater than a chrominance threshold and a red-green value less than a red-green threshold.

The method may include filtering the red-eye candidate regions to confirm or reject said regions as red-eye defect regions, and selecting a subset of the rejected red-eye candidate regions.

The method may be implemented within a digital image acquisition device. The method may be implemented as part of an image acquisition process. The method may be implemented as part of a playback option in the digital image acquisition device.

The method may be implemented to run as a background process in a digital image acquisition device. The method may be implemented within a general purpose computing device and wherein the acquiring may include receiving the digital image from a digital image acquisition device.

The candidate red-eye region and/or the region of high intensity pixels may be corrected. The region of high intensity pixels may be corrected after the red-eye candidate region. The correcting of the region of high intensity pixels may utilize corrected pixel values based on the candidate red-eye region. Results of correcting the candidate red-eye region and the region of high intensity pixels may be combined in such a manner as to obfuscate a seam between the regions. The method may include smoothing a seam region between the candidate red-eye region and the region of high intensity pixels.

The eye-related characteristic may include shape, roundness, and/or relative pupil size.

A further method is provided for digital image artifact correction. A digital image is acquired. A candidate red-eye defect region is identified in the image. A seed pixel is identified which has a high intensity value in the vicinity of the candidate red-eye region. An eye-related characteristic of a combined hybrid region is analyzed. The combined hybrid region includes the candidate red-eye region and the seed pixel. The combined hybrid region is identified as a flash artifact region based on the analyzing of the eye-related characteristic. Flash artifact correction is applied to the flash artifact region.

The flash artifact correction may include red-eye correction of the candidate red-eye region. The flash artifact correction may also include correction of a second region that includes the seed pixel.

The seed pixel may have a yellowness above a pre-determined threshold and a redness below a pre-determined threshold.

The method may include filtering the red-eye candidate regions to confirm or reject the regions as red-eye defect regions, and selecting a subset of the rejected red-eye candidate regions.

The method may be implemented within a digital image acquisition device. The method may be implemented as part of an image acquisition process. The method may be implemented as part of a playback option in the digital image acquisition device.

The method may be implemented to run as a background process in a digital image acquisition device. The method may be implemented within a general purpose computing device, and the acquiring may include receiving the digital image from a digital image acquisition device. The analyzing may include checking whether an average b value exceeds a relatively low threshold. The analyzing may include checking whether a difference between an average a value and the average b value is lower than a given threshold.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 illustrates an image in which several defect candidate regions have been identified and surrounded by bounding boxes;

Figure 2 shows in more detail a candidate region exhibiting a half-red half-white/golden defect; and

Figure 3 illustrates a flow diagram of an embodiment of image correction software according to the present invention.

The preferred embodiments provide improved methods for detecting defects in subjects' eyes as well as methods for correcting such defects.

A preferred embodiment may operate by examining a candidate red eye region, looking in its neighborhood or vicinity for a possible yellow, white and/or golden patch belonging to the same eye, and, if any, under certain conditions correcting one or both of the red-eye or golden patch.

Using a technique in accordance with a preferred embodiment, the quality and acceptability of automatic eye correction can be increased for half red - half white/golden defects.

Implementations of the preferred embodiments can take advantage of the red part of the eye defect being detected by one automatic red-eye detection processing method, perhaps utilizing a conventional technique or a new technique, so the detection of the non-red regions can be applied as a pre-correction stage, and so that this method may take full advantage of existing or new detection methods. The correction parts of such red-eye processing may be altered to implement a technique in accordance with a preferred embodiment, while non correction parts preferably are not altered.

A technique in accordance with a preferred embodiment may provide a qualitative improvement in image correction with relatively little processing overhead making it readily implemented in cameras that may have limited processing capability and/or without unduly effecting the camera click-to-click interval.

It will be seen that pixels belonging to a red-eye defect may be corrected by reducing the red value of the pixel. As an example, image information may be available in Luminance-Chrominance space such as L*a*b* color space. This may involve reducing the L* and a* value of a pixel to a suitable level. In many cases, reduction of the a* value may automatically restore the chrominance of the eye thus restoring a true value of the iris.

However, for white/golden pixels of a half red – half white/golden eye defect, the L and possibly b characteristics of the pixel may also be either saturated and/or distorted. This means that unlike red eye defects, in these cases the original image information may be partially or even totally lost. The correction may be performed by reducing the overall L* value as well as reduction of the a* and b*. However, because L* may be very high, the chrominance may be very low, thus there may not be significant color information remaining. In an additional preferred embodiment, correction of the white/golden portion of the defect involves reconstructing the eye, as opposed to the restoration described above from information from the corrected red eye portion of the defect.

Referring now to Figure 3, a digital image 10 may be acquired 30 in an otherwise conventional manner and/or utilizing some innovative technique. Where the embodiment is implemented in a device separate from a device such as a camera or scanner on which the image was originally acquired, the image may be acquired through file transfer by another suitable means including wired or wireless peer-to-peer or network transfer. Otherwise the image correction process described below, if suitably speed optimized, can either be implemented within the image acquisition chain of the image acquisition device for displaying a corrected image to a user before the user chooses to save and/or acquire a subsequent image; or alternatively, the image correction process can be analysis optimized to operate in the background on the image acquisition device on images which have been stored previously.

Next, during red-eye detection 32, red-pixels 20 are identified and subsequently grouped into regions 22 comprising a plurality of contiguous (or generally contiguous) pixels (see, e.g., Figure 2). These regions can be associated 34 with larger bounding box regions 12,14,16,18 (see, e.g., Figure 1). The candidate regions contained within these bounding boxes are then passed through a set of filters 36 to determine whether the regions are in fact red-eye defects or not. Examples of such falsing filters are disclosed in US 6,873,743.

One possible reason a filtering process might reject a candidate region, such as a region of red-pixels 20 as illustrated at Figure 2, is that it lacks the roundness expected of a typical red-eye defect. Such regions as well as regions failed for other suitable reasons may be preferably passed as rejected regions 38 for further processing to determine if they include a half red – half white/golden eye defect – and if so for the defect to be corrected accordingly. Much of the operation of this processing can be performed in parallel with other red-eye processing (in

for example a multi-processing environment) or indeed processing for each rejected region could be carried out to some extent in parallel.

Processing in accordance with an exemplary embodiment which may be involved in checking for half red – half white/golden eye defects is outlined in more detail as follows:

1. The bounding box 12-18 of an already detected red part of the eye artifact is searched 40 for a point, say 26 (see Figure 2) having:

    a. High intensity (I > threshold)

    b. High yellowness (b > threshold)

    c. Low redness (a < threshold)

    In this example, it is assumed that the image information for a region is available in Lab color space, although another embodiment could equally be implemented for image information in other formats such as RGB, YCC or indeed bitmap format.

    If such a point does not exist, then STOP (i.e., the decision is taken that no white/golden patch exists in the vicinity of the red area) and confirm that the region is to be rejected 42.

2. Starting from a point detected in Step 40, grow 44 a region 24 (see Figure 2) based on luminance information, for example, if luminance is greater than a threshold, a point is added to the white/golden region 24. If the region 24 exceeds a predefined maximum allowable size, step 46, then STOP and confirm that the region is to be rejected 42. The maximum allowable size can be determined from a ratio of the bounding box area vis-à-vis the overall area of the red 22 and white/golden region 24.

3. Yellowness and non-pinkness of the white region are then assessed 48 by checking that average b value exceeds a relatively low threshold, and the difference between average "a" and average "b" is lower than a given threshold. If at least one test fails, then STOP and confirm that the region is to be rejected 42.

4. In this embodiment, the increase of roundness of the combination of initial red 22 and detected white/golden regions 24 from the original red region 22 is checked 50. Thus, the roundness of the union of the red and white/golden regions is computed and

compared with that of the red region 22. If roundness is less than a threshold value or decreased or not increased sufficiently by "adding" the white/golden region 24 to the red one 22, then STOP and reject the region 42. Roundness of a region is preferably computed using the formula

$$\text{Roundness} = \frac{\text{Perimeter}^2}{4\pi \cdot \text{Area}}$$

Prior to assessing roundness, a hole filling procedure is preferably applied to each region 22,24 to include for example pixel 28 within the union.

5. If the region passes one or more and preferably all of the above tests, it is added to the list of confirmed red-eye regions. At this point, the red part of the eye defect can be corrected 52 in any of various manners, for example, by reducing the a value of pixels in Lab color space, while the pixels that were corrected are marked to be used in further processing.

6. For white/golden regions that were added to the list of red-eye defect regions, further correction of the white/golden portion of the defect can be applied, after some further checks. One such check is to detect glint 54. In RGB space, glint candidates are selected as high luminance pixels (for example, min(R, G) >= 220 and max(R, G) == 255). If a very round (e.g, in one or both of aspect ratio and elongation), luminous, and desaturated region is found within the interior of the current "red $\cup$ white" region 22,24, its pixels may be removed from the "pixels-to-correct" list. The glint may be the entire high luminance region but in most cases only a small part of the high luminance region will satisfy the criteria for glint pixels.

7. Where a glint is not detected or is small relative to the size of the white/golden region, the non-red eye artifact pixels 24 can be corrected 56 preferably taking color information from red pixels 22 which where already corrected at step 52, if such information after the correction exists. Alternatively, the correction can be done by reduction of the Luminance value. In the preferred embodiment, color information is derived from a selection of ex-red pixels with L and b values which lie in the median for that region (between the 30% and 70% points on a cumulative histogram for L and b). These color samples (from the already corrected red part of the eye) are used to

create the same texture on both the red and non-red defect parts of the eye. It should be noted that the L and b histograms may be generally available from preprocessing steps, for example, those for determining various thresholds, and won't necessarily have changed during correction as the red correction may just involve reducing the a value of a pixel. It is possible that the correction of the red-eye region and the one for the high intensity region may show an unpleasant seam between the regions. In an alternative embodiment, the corrected region will be smoothed in such a manner that the seams between the two regions if exist, will be eliminated.

In methods that may be performed according to preferred embodiments herein and that may have been described above and/or claimed below, the operations have been described in selected typographical sequences. However, the sequences have been selected and so ordered for typographical convenience and are not intended to imply any particular order for performing the operations.

Claims:

1. A method for digital image artifact correction comprising:

acquiring a digital image;

identifying a candidate red-eye defect region in said image;

identifying a region of high intensity pixels having at least a threshold intensity value in a vicinity of said candidate red-eye region;

analyzing an eye-related characteristic of a combined hybrid region including said candidate red-eye region and said region of high intensity pixels; and

identifying said combined hybrid region as a flash artifact region based on said analyzing of said eye-related characteristic; and

applying flash artifact correction to said flash artifact region.

2. A method as claimed in claim 1, further comprising defining a bounding box that contains said candidate red-eye defect region.

3. A method as claimed in claim 2, wherein identifying said region of high intensity pixels comprises identifying a seed high intensity pixel located within said bounding box.

4. A method as claimed in claim 3, wherein said seed pixel has a yellowness above a pre-determined threshold and a redness below a pre-determined threshold.

5. A method as claimed in claim 3, further comprising defining said region of high intensity pixels around said seed pixel.

6. A method as claimed in claim 5, wherein said analyzing comprises calculating a difference in roundness between said candidate red-eye region and said combined hybrid region.

7. A method as claimed in claim 6, further comprising determining to apply said red-eye correction when a roundness of the combined hybrid region is greater than a threshold value.

8. A method as claimed in claim 6, further comprising determining to apply said red-eye correction when a roundness of the combined hybrid region is greater than a roundness of the candidate red-eye region by a threshold amount.

9. A method as claimed in claim 5, further comprising determining to not apply correction when said region of high intensity pixels comprises greater than a threshold area.

10. A method as claimed in claim 9, wherein said area is determined as a relative function to a size of said bounding box.

11. A method according to claim 5, further comprising determining a yellowness and a non-pinkness of said region of high intensity pixels.

12. A method as claimed in claim 11, wherein said acquired image is in LAB color space, and wherein the method further comprises measuring an average b value of said region of high intensity pixels and determining a difference between an average a value and the average b value of said region of high intensity pixels.

13. A method as claimed in claim 5, wherein said analyzing further comprises analyzing said combined hybrid region for the presence of a glint, and determining to not correct said region of high intensity pixels responsive to the presence of glint.

14. A method as claimed in claim 5, further comprising correcting said region of high intensity pixels by selecting one or more pixel values from a corrected red-eye region and employing said pixel values to correct said region of high intensity pixels.

15. A method as claimed in claim 14, wherein said selected pixel values are taken from pixels having L and b values falling within a median for the corrected red-eye region.

16. A method as claimed in claim 1, further comprising determining to not apply correction when an average b value of said region of high intensity pixels exceeds a relatively low threshold or if a difference between average a and b values is lower than a pre-determined threshold.

17. A method as claimed in claim 1, further comprising converting said acquired image to one of RGB, YCC or Lab color space formats, or combinations thereof.

18. A method as claimed in claim 1, wherein said analyzing of said acquired image is performed in Luminance-chrominance color space and said region of high intensity pixels has a luminance value greater than a luminance threshold, and blue-yellow chrominance values greater than a chrominance threshold and a red-green value less than a red-green threshold.

19. A method as claimed in claim 1, further comprising:

filtering said red-eye candidate regions to confirm or reject said regions as red-eye defect regions; and

selecting a subset of said rejected red-eye candidate regions for analysis as hybrid regions.

20. A method as claimed in claim 1, and implemented within a digital image acquisition device.

21. A method as claimed in claim 20, and implemented as part of an image acquisition process.

22. A method as claimed in claim 20, and implemented as part of a playback option in said digital image acquisition device.

23. A method as claimed in claim 1, and implemented to run as a background process in a digital image acquisition device.

24. A method as claimed in claim 1, and implemented within a general purpose computing device and wherein said acquiring comprises receiving said digital image from a digital image acquisition device.

25. A method as claimed in claim 1, wherein said flash artifact correction includes red eye correction of said candidate red-eye region.

26. A method as claimed in claim 25, wherein said flash artifact correction further comprises correction of said region of high intensity pixels.

27. A method as claimed in claim 25, wherein correcting said region of high intensity pixels comprises using corrected pixel values based on said candidate red-eye region.

28. A method as claimed in claim 25, wherein results of correcting said candidate red-eye region and said region of high intensity pixels are combined in such a manner as to obfuscate a seam between the regions.

29. A method as claimed in claim 25, further comprising smoothing a seam region between said candidate red-eye region and said region of high intensity pixels.

30. A method as claimed in claim 1, wherein said eye-related characteristic comprises shape.

31. A method as claimed in claim 1, wherein said eye-related characteristic comprises roundness.

32. A method as claimed in claim 1, wherein said eye-related characteristic comprises relative pupil size.

33. A method for digital image artifact correction, comprising:

acquiring a digital image;

identifying a candidate red-eye defect region in said image;

identifying a seed pixel having a high intensity value in the vicinity of said candidate red-eye region;

analyzing an eye-related characteristic of a combined hybrid region including said candidate red-eye region and said seed pixel;

identifying said combined hybrid region as a flash artifact region based on said analyzing of said eye-related characteristic; and

applying flash artifact correction to said flash artifact region.

34. A method as claimed in claim 33, wherein said seed pixel has a yellowness above a pre-determined threshold and a redness below a pre-determined threshold.

35. A method as claimed in claim 33, further comprising:

filtering said red-eye candidate regions to confirm or reject said regions as red-eye defect regions; and

selecting a subset of said rejected red-eye candidate regions for analysis as hybrid regions.

36. A method as claimed in claim 33, and implemented within a digital image acquisition device.

37. A method as claimed in claim 36, and implemented as part of an image acquisition process.

38. A method as claimed in claim 36, and implemented as part of a playback option in said digital image acquisition device.

39. A method as claimed in claim 33, and implemented to run as a background process in a digital image acquisition device.

40. A method as claimed in claim 33, and implemented within a general purpose computing device and wherein said acquiring comprises receiving said digital image from a digital image acquisition device.

41. A method as claimed in claim 33, wherein the analyzing comprises checking whether an average b value exceeds a relatively low threshold.

42. A method as claimed in claim 41, wherein the analyzing comprises checking whether a difference between an average a value and the average b value is lower than a given threshold.

43. A method as claimed in claim 33, wherein said flash artifact correction includes red eye correction of said candidate red-eye region.

44. A method as claimed in claim 43, wherein said flash artifact correction further comprises correction of a second region that includes said seed pixel.

45. A computer program product comprising computer readable code for digital image artifact correction which when executed on an image processing apparatus is arranged to perform the steps of any one of claims 1 to 44.

46. An apparatus configured for correcting digital image artifact, comprising:

means for acquiring a digital image;

means for identifying a candidate red-eye defect region in said image;

means for identifying a region of high intensity pixels having at least a threshold intensity value in a vicinity of said candidate red-eye region;

means for analyzing an eye-related characteristic of a combined hybrid region including said candidate red-eye region and said region of high intensity pixels;

means for identifying said combined hybrid region as a flash artifact region based on said analyzing of said eye-related characteristic; and

means for applying flash artifact correction to said flash artifact region.

47. An apparatus as claimed in claim 46, further comprising means for defining a bounding box around said candidate red-eye defect region.

48. An apparatus as claimed in claim 46, wherein said means for analyzing further comprises means for analyzing said combined hybrid region for the presence of a glint, and further comprising means for determining to not correct said region of high intensity pixels responsive to the presence of glint.

49. An apparatus as claimed in claim 46, further comprising:

means for filtering said red-eye candidate regions to confirm or reject said regions as red-eye defect regions; and

means for selecting a subset of said rejected red-eye candidate regions for analysis as hybrid regions.

50. An apparatus as claimed in claim 46, wherein said flash artifact correction includes red eye correction of said candidate red-eye region.

51. An apparatus configured for digital image artifact correction, comprising:

means acquiring a digital image;

means for identifying a candidate red-eye defect region in said image;

means for identifying a seed pixel having a high intensity value in the vicinity of said candidate red-eye region;

means for analyzing an eye-related characteristic of a combined hybrid region including said candidate red-eye region and said seed pixel;

means for identifying said combined hybrid region as a flash artifact region based on said analyzing of said eye-related characteristic; and

means for applying flash artifact correction to said flash artifact region.

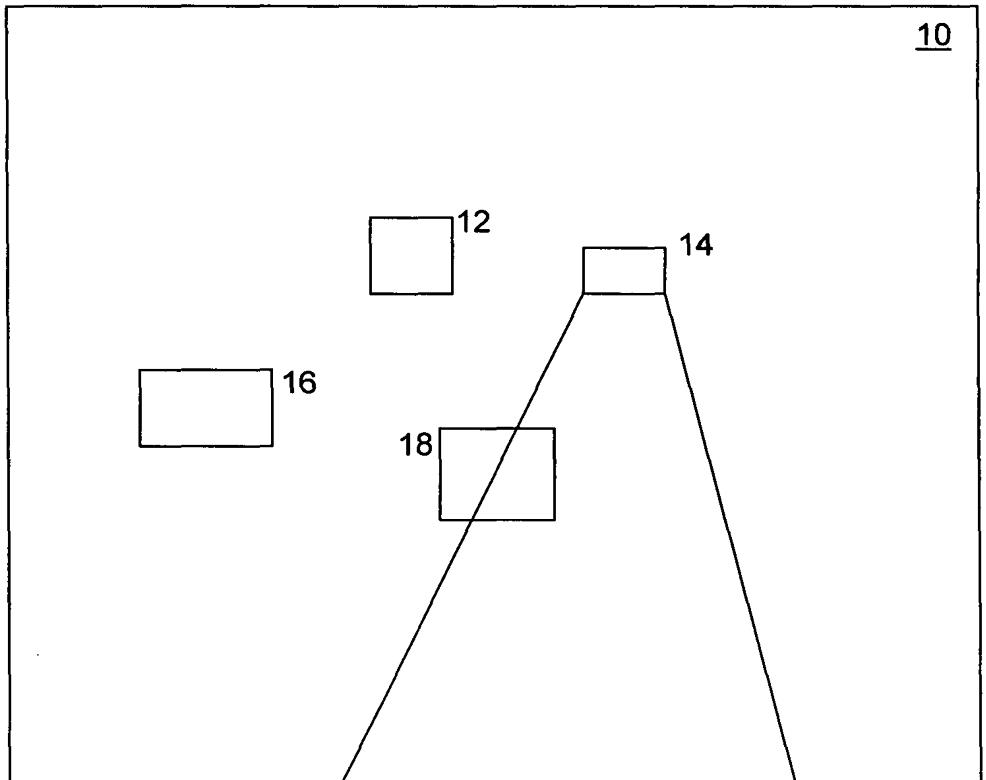


Figure 1

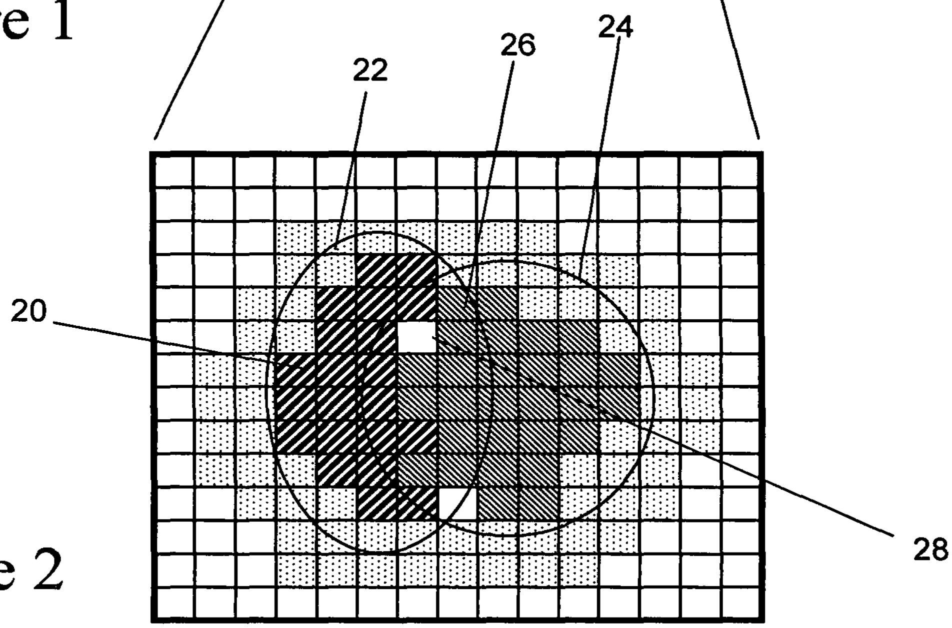


Figure 2

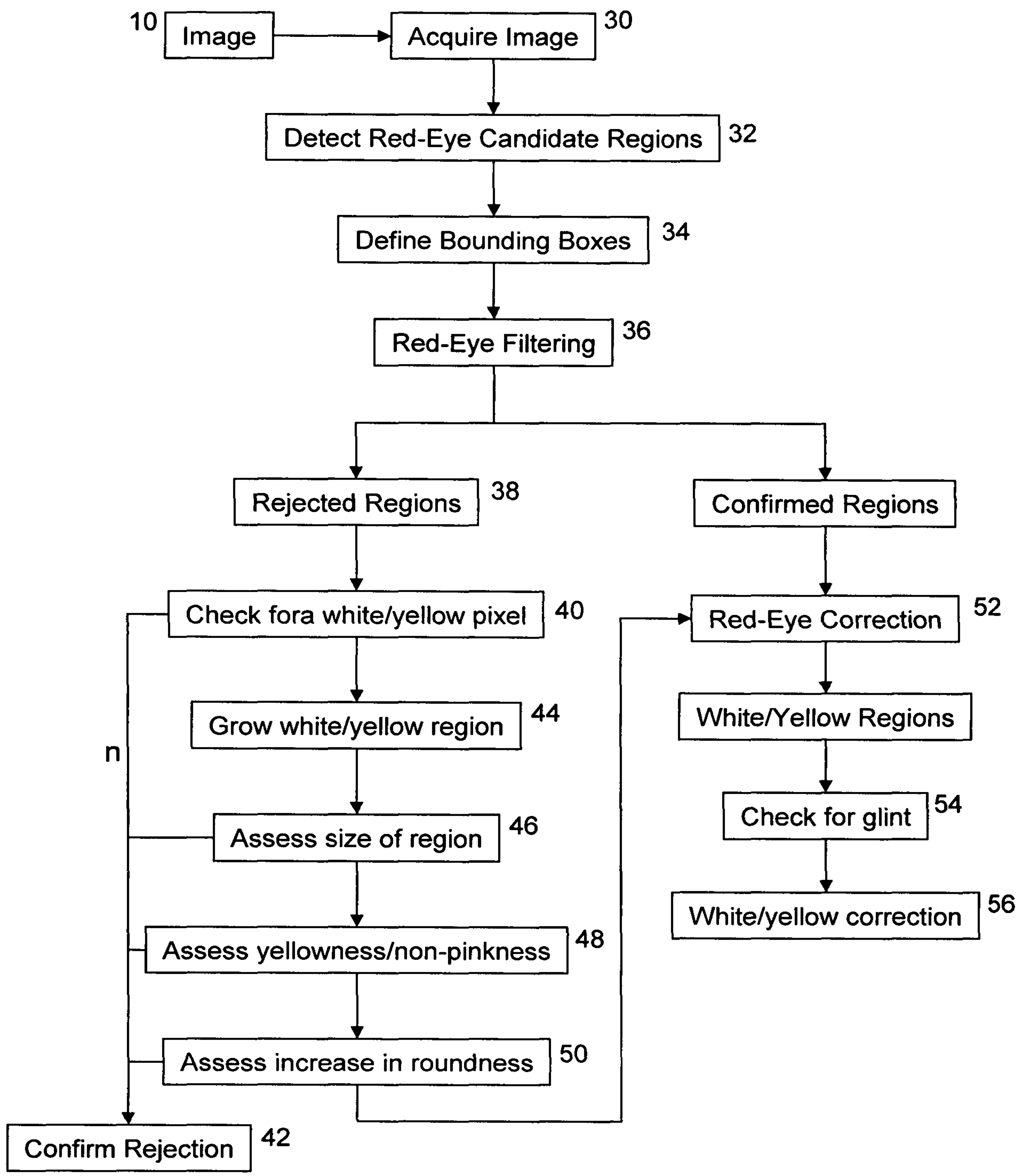

10
Image
Acquire Image
30
Detect Red-Eye Candidate Regions
32
Define Bounding Boxes
34
Red-Eye Filtering
36
Rejected Regions
38
Confirmed Regions
Check fora white/yellow pixel
40
Red-Eye Correction
52
Grow white/yellow region
44
White/Yellow Regions
n
Check for glint
54
Assess size of region
46
White/yellow correction
56
Assess yellowness/non-pinkness
48
Assess increase in roundness
50
Confirm Rejection
42

Figure 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/008342

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06T5/00
ADD. G06T7/40

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1 528 509 A (NORITSU KOKI CO LTD [JP]) 4 May 2005 (2005-05-04) abstract; figures 1-10 paragraph [0002] - paragraph [0012] paragraph [0017] - paragraph [0050]	1-51
A	US 6 407 777 B1 (DELUCA MICHAEL JOSEPH [US]) 18 June 2002 (2002-06-18) the whole document	1-51
A	SMOLKA B ET AL: "Towards automatic redeye effect removal" PATTERN RECOGNITION LETTERS, NORTH-HOLLAND PUBL. AMSTERDAM, NL, vol. 24, no. 11, July 2003 (2003-07), pages 1767-1785, XP004416063 ISSN: 0167-8655 the whole document	1-51
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 December 2006	28/12/2006

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Herter, Jochen

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GAUBATZ M ET AL: "Automatic red-eye detection and correction" PROCEEDINGS 2002 INTERNATIONAL CONFERENCE ON IMAGE PROCESSING. ICIP 2002. ROCHESTER, NY, SEPT. 22 - 25, 2002, INTERNATIONAL CONFERENCE ON IMAGE PROCESSING, NEW YORK, NY : IEEE, US, vol. VOL. 2 OF 3, 22 September 2002 (2002-09-22), pages 804-807, XP010607446 ISBN: 0-7803-7622-6 the whole document -----	1-51
A	EP 1 199 672 A2 (XEROX CORP [US]) 24 April 2002 (2002-04-24) the whole document -----	1-51
A	US 6 873 743 B2 (STEINBERG ERAN [US]) 29 March 2005 (2005-03-29) cited in the application the whole document -----	1-51
A	WO 03/071484 A (PIXOLOGY LTD [GB]; JARMAN NICK [GB]; LAFFERTY RICHARD [GB]; ARCHIBALD) 28 August 2003 (2003-08-28) cited in the application the whole document -----	1-51

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2006/008342

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP 1528509	A	04-05-2005	CN	1612164 A	04-05-2005
			JP	2005128942 A	19-05-2005
			US	2005117173 A1	02-06-2005
US 6407777	B1	18-06-2002	NONE		
EP 1199672	A2	24-04-2002	JP	2002163649 A	07-06-2002
			US	6718051 B1	06-04-2004
US 6873743	B2	29-03-2005	US	6904168 B1	07-06-2005
			US	2002176623 A1	28-11-2002
			US	2002159630 A1	31-10-2002
			US	2004208361 A1	21-10-2004
WO 03071484	A	28-08-2003	AU	2003201021 A1	09-09-2003
			CA	2477087 A1	28-08-2003
			EP	1476851 A1	17-11-2004
			GB	2385736 A	27-08-2003
			JP	2005518050 T	16-06-2005
			US	2004240747 A1	02-12-2004